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FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER **L9289.01129** U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR **New PCT Application** 09/807287
INTERNATIONAL APPLICATION NO. **PCT/JP00/05622**	INTERNATIONAL FILING DATE **August 23, 2000**	PRIORITY DATE CLAIMED **August 27, 1999**

TITLE OF INVENTION
COMMUNICATION TERMINAL APPARATUS AND CHANNEL ESTIMATION METHOD

APPLICANT(S) FOR DO/EO/US
Katsuhiko HIRAMATSU

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Claim for Priority with PCT/IB/304
PCT/IB/308
PCT/RO/101

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U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR) 09/807287 * New PCT Application	INTERNATIONAL APPLICATION NO. PCT/JP00/05622	ATTORNEY'S DOCKET NUMBER L9289.01129

21. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

	CALCULATIONS	PTO USE ONLY
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1,000.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO **$860.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	8 - 20 =	0	x $18.00	**$0.00**	
Independent claims	3 - 3 =	0	x $80.00	**$0.00**	
Multiple Dependent Claims **(check if applicable).**			☐	**$0.00**	
	TOTAL OF ABOVE CALCULATIONS =			**$860.00**	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).**			☐	**$0.00**	
	SUBTOTAL =			**$860.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	**$0.00**	
	TOTAL NATIONAL FEE =			**$860.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☒	**$40.00**	
	TOTAL FEES ENCLOSED =			**$900.00**	
				Amount to be: refunded	$
				charged	$

☒ A check in the amount of **$900.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **19-4375** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

James E. Ledbetter
STEVENS, DAVIS, MILLER & MOSHER, L.L.P.
1615 L Street, NW, Suite 850
Washington, DC 20036
Tel: 202/785-0100
Fax: 202/408-5200

James E. Ledbetter
SIGNATURE

James E. Ledbetter
NAME

28,732
REGISTRATION NUMBER

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DESCRIPTION

COMMUNICATION TERMINAL APPARATUS AND CHANNEL ESTIMATION METHOD

Technical Field

The present invention relates to a CDMA-based communication terminal apparatus and channel estimation method used in a radio communication system such as automobile telephone and cellular telephone.

Background Art

In a radio communication system, transmission diversity may be used on the base station side in order to increase reception power of transmission signals of individual channels (hereinafter referred to as "individual channel signals") on the communication terminal side by sending individual channel signals to one communication terminal from a plurality of diversity antennas.

FIG.1 is a system configuration diagram of a system disclosed in the 3GPP WG1 TSG-RAN WG1 R1-99832 (Physical channels and mapping of transport channels onto physical channels (FDD)), as one example of a radio communication system using transmission diversity.

As shown in FIG.1, base station 1 transmits common pilot channel transmission signal (hereinafter referred to as "common pilot channel signal") A from antenna A

and transmits common pilot channel signal B from antenna B. At the same time, base station 1 transmits individual channel signal A to communication terminal 2 from antenna A and transmits individual channel signal B to communication terminal 2 from antenna B.

Since individual channel signal A and individual channel signal B are multiplied by a same spreading code at base station 1, communication terminal 2 receives individual channel signal A and individual channel signal B as one inseparable signal.

On the other hand, common pilot channel signal A and common pilot channel signal B are multiplied by different spreading codes. Or even if these two signals are multiplied by a same spreading code, these are made separable in some way. Therefore, communication terminal 2 can separate common pilot channel signal A from common pilot channel signal B. Moreover, individual channel signal A and common pilot channel signal A, and individual channel signal B and common pilot channel signal B are received through a same propagation path respectively, and therefore it is possible to know a phase rotation angle of individual channel signal B with respect to individual channel signal A by carrying out channel estimations of common pilot channel signal A and common pilot channel signal B.

FIG.2 is a block diagram showing a configuration of a conventional communication terminal. In the

communication terminal shown in FIG.2, antenna 11 receives a signal transmitted from a base station and sends a signal to the base station. Duplexer 12 switches between time zones of transmission and reception. Reception RF section 13 amplifies the reception signal that passes duplexer 12 and converts the frequency of the reception signal to a baseband signal.

Despreading section 14 despreads the output signal of reception RF section 13 with a spreading code of an individual channel signal and extracts a modulated signal of an individual channel signal. Likewise, despreading section 15 despreads the output signal of reception RF section 13 with a spreading code of a common pilot channel signal A and extracts a modulated signal of common pilot channel signal A. Likewise, despreading section 16 despreads the output signal of reception RF section 13 with a spreading code of a common pilot channel signal B and extracts a modulated signal of common pilot channel signal B.

Channel estimation section 17 estimates (so-called "channel estimation") the phase and amplitude of a propagation path using pilot symbols in the modulated signal of the individual channel signal output from despreading section 14. In the following explanations, the phase and amplitude of an estimated propagation path will be referred to as a "channel estimation value".

Likewise, channel estimation section 18 performs a channel estimation using pilot symbols in the modulated

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signal of common pilot channel signal A output from despreading section 15 and channel estimation section 19 performs a channel estimation using pilot symbols in the modulated signal of common pilot channel signal B output from despreading section 16.

Demodulation section 20 demodulates the modulated signal of the individual channel signal output from despreading section 14 based on the channel estimation value output from channel estimation section 17.

Phase rotation control section 21 generates a phase rotation control signal that indicates the base station an amount of phase rotation based on a phase difference between common pilot channel signal A output from channel estimation section 18 and common pilot channel signal B output from channel estimation section 19.

Multiplexing section 22 multiplexes the transmission signal and the phase rotation control signal output from phase rotation control section 21. Modulation section 23 performs primary modulation processing such as QPSK on the output signal of multiplexing section 22. Spreading section 24 spreads the output signal of modulation section 23 by multiplying it by a specific spreading code. Transmission RF section 25 converts the frequency of the output signal of spreading section 24 to a radio frequency and transmits the signal by radio from antenna 11 via duplexer 12.

Then, a relationship between phase difference δ between individual channel signals and a channel

estimation value estimated by channel estimation section 17 will be explained using FIG.3A and FIG.3B.

FIG.3A shows channel estimation values when phase difference δ between individual channel signal A and individual channel signal B is $-90° \leqq \delta \leqq 90°$, while FIG.3B shows channel estimation values when phase difference δ between individual channel signal A and individual channel signal B is $90° \leqq \delta \leqq 270°$.

In FIG.3A and FIG.3B, channel estimation value $\beta(n)$ is expressed as a synthesized vector of channel estimation value $\beta a(n)$ of individual channel signal A and channel estimation value $\beta b(n)$ of individual channel signal B. Moreover, a channel estimation value resulting from a synthesis of $-\beta b(n)$ obtained by rotating $\beta b(n)$ by 180° and $\beta a(n)$ is expressed as $\beta'(n)$.

The longer the vectors of channel estimation values $\beta(n)$ and $\beta'(n)$, the greater the reception power of the communication terminal becomes and the reception quality improves.

As shown in FIG.3A, when phase difference δ between individual channel signal A and individual channel signal B is $-90° \leqq \delta \leqq 90°$, $\beta(n)$ is greater than $\beta'(n)$.

On the other hand, as shown in FIG.3B, when phase difference δ between individual channel signal A and individual channel signal B is $90° \leqq \delta \leqq 270°$, $\beta'(n)$ is greater than $\beta(n)$.

That is, when $90° \leqq \delta \leqq 270°$, transmitting individual channel signal B rotated by 180° makes it

possible to increase reception power at the communication terminal.

As shown above, in a radio communication system using transmission diversity, the reception quality can be improved by the communication terminal controlling the amount of phase rotation by carrying out channel estimations of common pilot channel signal A and common pilot channel signal B and the base station transmitting individual channel signal B by rotating its phase as appropriate based on the amount of phase rotation control and thereby increasing the reception power of the individual channel signals at the communication terminal.

However, when the base station rotates the phase of the individual channel signals for every slot as appropriate, the reception slots at the communication terminal become discontiguous, and therefore the conventional communication terminal above fails to average channel estimation values over a plurality of slots, having a problem of decreasing the reliability of channel estimation values compared to a case where transmission diversity is not used.

Disclosure of Invention

It is an object of the present invention to provide a communication terminal apparatus and channel estimation method in a radio communication system using transmission diversity capable of improving the

reliability of channel estimation values.

This object is attained by estimating the amount of phase rotation of common pilot channel signals with respect to individual channel signals and carrying out channel estimations using common pilot channel signals with greater transmit power than that of individual channel signals.

Brief Description of Drawings

FIG.1 is a system configuration diagram of a radio communication system using transmission diversity;

FIG.2 is a block diagram showing a configuration of a conventional communication terminal;

FIG.3A illustrates a relationship between an amount of phase rotation and channel estimation values;

FIG.3B illustrates a relationship between an amount of phase rotation and channel estimation values;

FIG.4 is a block diagram showing a configuration of the transmitting side of a base station that carries out radio communication with a communication terminal of the present invention;

FIG.5 is a block diagram showing a configuration of a communication terminal according to Embodiment 1 of the present invention;

FIG.6A illustrates a relationship of channel estimation values according to Embodiment 1 of the present invention;

FIG.6B illustrates a relationship of channel

estimation values according to Embodiment 1 of the present invention;

FIG.7 illustrates a relationship of channel estimation values according to Embodiment 2 of the present invention;

FIG.8 is a block diagram showing a configuration of a communication terminal according to Embodiment 2 of the present invention;

FIG.9 is a block diagram showing a configuration of a communication terminal according to Embodiment 3 of the present invention; and

FIG.10 is a block diagram showing an internal configuration of a multiple channel estimation value synthesis section of the communication terminal according to Embodiment 3 of the present invention.

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Best Mode for Carrying out the Invention

With reference now to the attached drawings, embodiments of the present invention will be explained in detail below.

FIG.4 is a block diagram showing a configuration of the transmitting side of a base station that carries out radio communication with a communication terminal of the present invention.

In the base station shown in FIG.4, modulation section 101 performs primary modulation processing such as QPSK on a transmission signal. Modulation section 102

performs primary modulation processing such as QPSK on common pilot channel signal A. Modulation section 103 performs primary modulation processing such as QPSK on common pilot channel signal B.

Spreading section 104 spreads the output signal of modulation section 101 by multiplying it by a specific spreading code. Spreading section 105 spreads the output signal of modulation section 102 by multiplying it by a specific spreading code. Spreading section 106 spreads the output signal of modulation section 103 by multiplying it by a specific spreading code.

Phase rotation section 107 rotates the phase of the output signal of spreading section 104 by a predetermined amount based on a phase rotation control signal that indicates the amount of phase rotation included in the signal transmitted from the communication terminal.

Multiplexing section 108 multiplexes the output signal of spreading section 104 and the output signal of spreading section 105. Multiplexing section 109 multiplexes the output signal of phase rotation section 107 and the output signal of spreading section 106.

Transmission RF section 110 converts the frequency of the output signal of multiplexing section 108 to a radio frequency, amplifies and sends the output signal by radio from antenna 112. Transmission RF section 111 converts the frequency of the output signal of multiplexing section 109 to a radio frequency, amplifies and sends the output signal by radio from antenna 113.

By the way, the following explanations assume that the amount of phase rotation at phase rotation section 107 of the base station is two kinds, "0° " and "180° ".

(Embodiment 1)

Embodiment 1 will describe a case where the base station transmits individual channel signal A and individual channel signal B without changing their amplitudes.

FIG.5 is a block diagram showing a configuration of a communication terminal according to Embodiment 1 of the present invention.

In the communication terminal shown in FIG.5, antenna 201 receives a signal transmitted from the base station and sends a signal to the base station. Duplexer 202 switches between time zones of transmission and reception. Reception RF section 203 amplifies the reception signal that passes duplexer 202 and converts the frequency of the reception signal to a baseband signal.

Despreading section 204 despreads the output signal of reception RF section 203 with a spreading code of an individual channel signal and extracts a modulated signal of the individual channel signal. Likewise, despreading section 205 despreads the output signal of reception RF section 203 with a spreading code of common pilot channel signal A and extracts a modulated signal of common pilot channel signal A. Likewise, despreading

section 206 despreads the output signal of reception RF section 203 with a spreading code of common pilot channel signal B and extracts a modulated signal of common pilot channel signal B.

Channel estimation section 207 estimates (so-called "channel estimation") the phase and amplitude of a propagation path using pilot symbols in the modulated signal of the individual channel signal output from despreading section 204.

Likewise, channel estimation section 208 performs a channel estimation using pilot symbols in the modulated signal of common pilot channel signal A output from despreading section 205 and channel estimation section 209 performs a channel estimation using pilot symbols in the modulated signal of common pilot channel signal B output from despreading section 206.

Phase rotation amount estimation section 210 estimates the amount of phase rotation based on the channel estimation values output from channel estimation sections 207, 208 and 209. By the way, a concrete method of estimating the amount of phase rotation in phase rotation amount estimation section 210 will be described later.

Channel estimation value synthesis section 211 synthesizes channel estimation values of common pilot channel signals based on the amount of phase rotation estimated by phase rotation amount estimation section 210 and outputs a final channel estimation value. By the

way, a concrete method of synthesizing channel estimation values by channel estimation value synthesis section 211 will be described later.

Demodulation section 212 demodulates the modulated signal of the individual channel signal output from despreading section 204 based on the channel estimation value output from channel estimation value synthesis section 211 and extracts the reception signal.

Phase rotation control section 213 generates a phase rotation control signal that indicates the base station an amount of phase rotation based on a phase difference between common pilot channel signal A output from channel estimation section 208 and common pilot channel signal B output from channel estimation section 209.

In this embodiment, the amount of phase rotation in phase rotation section 107 of the base station is two kinds, "0°" and "180°", and therefore phase rotation control section 213 outputs a phase rotation control signal instructing that the amount of phase rotation be set to "0°" when phase difference δ between common pilot channel signal A and common pilot channel signal B is $-90° \leqq \delta \leqq 90°$ and the amount of phase rotation be set to "180°" otherwise.

Multiplexing section 214 multiplexes the transmission signal with the phase rotation control signal output from phase rotation control section 213. Modulation section 215 performs primary modulation

processing such as QPSK on the output signal of multiplexing section 214. Spreading section 216 spreads the output signal of modulation section 215 by multiplying it by a specific spreading code. Transmission RF section 217 converts the frequency of the output signal of spreading section 216 to a radio frequency, amplifies and sends the signal by radio from antenna 201 via duplexer 202.

Then, a relationship of values of channel estimations carried out by channel estimation sections 207, 208 and 209 will be explained using FIG.6A and FIG.6B.

FIG.6A shows a relationship of channel estimation values when the amount of phase rotation is "0°" and FIG.6B shows a relationship of channel estimation values when the amount of phase rotation is "180°".

The following explanations assume that the channel estimation value of individual channel signal A is $\beta a(n)$ and the channel estimation value of individual channel signal B is $\beta b(n)$. In this case, channel estimation value $\beta(n)$ of the individual channel signal is expressed as a vector synthesized from $\beta a(n)$ and $\beta b(n)$.

Furthermore, suppose the channel estimation value of common pilot channel signal A is $\alpha a(n)$ and the channel estimation value of common pilot channel signal B is $\alpha b(n)$.

When the amount of phase rotation is "0°" as shown

in FIG.6A, individual channel signal A and common pilot channel signal A have the same phase and propagation path, and therefore the vector of $\beta a(n)$ and the vector of $\alpha a(n)$ point in the same direction. Likewise, the vector of $\beta b(n)$ and the vector of $\alpha b(n)$ point in the same direction.

Furthermore, when the amplitudes of individual channel signal A and individual channel signal B are not changed at the base station, the amplitude ratio of $\alpha a(n)$ to $\beta a(n)$ is equal to the amplitude ratio of $\alpha b(n)$ to $\beta b(n)$.

Therefore, channel estimation value $\beta(n)$ of the individual channel signal points in the same direction as that of synthesis result $\alpha(n)$ of $\alpha a(n)$ and $\alpha b(n)$.

That is, when the amount of phase rotation is "0°", channel estimation is possible by synthesizing the channel estimation value of common pilot channel signal A and the channel estimation value of common pilot channel signal B.

On the other hand, as shown in FIG.6B, when the amount of phase rotation is "180°", the phase of individual channel signal B is rotated by 180° from the phase of common pilot channel signal B, and therefore the vector of $\beta b(n)$ and the vector of $\alpha b(n)$ point in different directions. Therefore, unlike the case of the amount of phase rotation of "0°", it is not possible to perform channel estimation using the result of a synthesis of channel estimation values of common pilot

channel signals.

However, the vector of $-\alpha b(n)$ obtained by rotating $\alpha b(n)$ by 180° points in the same direction as that of the vector of $\beta b(n)$. Thus, $\beta(n)$ points in the same direction as that of result $\alpha'(n)$ of a synthesis of $\alpha a(n)$ and $-\alpha b(n)$.

That is, when the amount of phase rotation is "180°", channel estimation is possible by synthesizing the channel estimation value of common pilot channel signal A and a value obtained by rotating the channel estimation value of common pilot channel signal B by 180°.

Thus, when it is possible to estimate the amount of phase rotation, channel estimation is possible based on a channel estimation value of a common pilot channel signal. Moreover, since a common pilot channel signal has greater transmit power than that of an individual channel signal, the reliability of a channel estimation value is higher than a case where an individual channel signal is used.

The method for estimating the amount of phase rotation in phase rotation amount estimation section 210 will be explained below.

When two channel estimation values are parallel, one channel estimation value is orthogonal to a complex conjugate of the other channel estimation value. The amplitudes of the two channel estimation values become a minimum when the two are orthogonal to each other.

For example, as described above, when the amount

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of phase rotation is "0°", channel estimation value β (n) of the individual channel signal points in the same direction as that of result α(n) of a synthesis of the channel estimation values of common pilot channel signals, and therefore β(n) is orthogonal to α^*(n), a complex conjugate of α(n).

From this relation, phase rotation amount estimation section 210 calculates synthesis value α'(n) of channel estimation value αa(n) of common pilot channel signal A and a value obtained by rotating the phase of channel estimation value αb(n) of common pilot channel signal B by θ from expression (1) below:

$$\alpha'(n) = \alpha a(n) + \exp(j\theta) \times \alpha b(n) \quad \cdots (1)$$

Then, phase rotation amount estimation section 210 calculates amplitude $X(\theta)$ about a predetermined candidate value of each θ (in this embodiment, two kinds of θ=0° and 180°), estimates the candidate value corresponding to a minimum of $X(\theta)$ as amount of phase rotation θ and outputs the amount of phase rotation θ to channel estimation value synthesis section 211.

$$X(\theta) = \mathrm{Re}[\alpha'^*(n)] \times \mathrm{Re}[\beta(n)] + \mathrm{Im}[\alpha'^*(n)] \times \mathrm{Im}[\beta(n)] \quad \cdots (2)$$

where, $(\cdot)^*$ denotes a complex conjugate, $\mathrm{Re}[\cdot]$ denotes a real part and $\mathrm{Im}[\cdot]$ denotes an imaginary part.

Since the communication terminal knows the phase rotation control signal sent to the base station, phase rotation amount estimation section 210 evaluates $X(\theta)$ using the phase rotation control signal first and when

$X(\theta)$ is smaller than a threshold, it is possible to estimate this θ as the amount of phase rotation θ. This provides a high probability that the amount of phase rotation can be estimated by one calculation, and thus it is possible to shorten the time required to estimate the amount of phase rotation.

Then, the method of calculating channel estimation values by channel estimation value synthesis section 211 will be explained.

Channel estimation value synthesis section 211 enters channel estimation value $\beta(n)$ of an individual channel signal from channel estimation section 207, channel estimation value $\alpha a(n)$ of common pilot channel signal A from channel estimation section 208 and channel estimation value $\alpha b(n)$ of common pilot channel signal B from channel estimation section 209 and amount of phase rotation θ from phase rotation amount estimation section 210.

Then, channel estimation value synthesis section 211 calculates final channel estimation value $\xi(n)$ from expression (3) below and outputs to demodulation section 212.

$$\xi(n) = \alpha a(n) + \exp(j\theta) \times \alpha b(n) + \beta(n) \quad \cdots (3)$$

Thus, since a common pilot channel signal has greater transmit power than that of an individual channel signal, it is possible to improve the reliability of channel estimation values by carrying out channel estimations based on the amount of phase rotation,

channel estimation values of a common pilot channel signal.

(Embodiment 2)

Embodiment 2 will describe a case where the base station carries out transmission by changing the amplitudes of individual channel signal A and individual channel signal B.

The relationship of channel estimation values in this embodiment will be explained using FIG.7.

Suppose the base station sets the amplitude of individual channel signal B "a" times (hereinafter this "a" will be referred to as "amplitude coefficient") the amplitude of individual channel signal A. When the amplitude ratio of $\alpha a(n)$ to $\beta a(n)$ is assumed to be k, the amplitude ratio of $\alpha b(n)$ to $\beta b(n)$ is $(k \times a)$.

In this case, as shown in FIG.7, channel estimation value $\beta(n)$ of an individual channel signal and synthesis value $\alpha(n)$ of common pilot channel signal A and common pilot channel signal B do not point in the same direction.

Thus, when the base station carries out transmission by changing the amplitudes of individual channel signal A and individual channel signal B, $\alpha(n)$ cannot be used as is for channel estimations, but it is necessary to take into account amplitude coefficient "a".

FIG.8 is a block diagram showing a configuration of a communication terminal according to Embodiment 2

of the present invention. In the communication terminal shown in FIG.8, the same components as those in the communication terminal in FIG.5 will be assigned the same reference numerals as those in FIG.5 and explanations thereof will be omitted.

The communication terminal shown in FIG.8 has a configuration of the communication terminal shown in FIG.5 with amplitude/phase rotation amount estimation section 301 added instead of phase rotation amount estimation section 210.

Amplitude/phase rotation amount estimation section 301 first calculates a synthesis value $\alpha'(n)$ of channel estimation value $\alpha a(n)$ of common pilot channel signal A and a value obtained by rotating the phase of channel estimation value $\alpha b(n)$ of common pilot channel signal B by θ from expression (4) below:

$$\alpha'(n)=\alpha a(n)+a\times\exp(j\theta)\times\alpha b(n) \quad \cdots (4)$$

Then, amplitude/phase rotation amount estimation section 301 calculates amplitude $X(a,\theta)$ about predetermined candidate values of each θ (in this embodiment, two types of $\theta=0°, 180°$) and predetermined candidate values of each amplitude coefficient "a" (e.g., a=0.5, 1.0, 2.0, etc.) from expression (5) below, estimates the combination of candidate values corresponding to a minimum of $X(\theta)$ as amplitude coefficient "a" and the amount of phase rotation θ and outputs amplitude coefficient "a" and the amount of phase rotation θ to channel estimation value synthesis

section 211.

$$X(a,\theta)=Re[\alpha'^*(n)]\times Re[\beta(n)]+Im[\alpha'^*(n)]\times Im[\beta(n)] \quad \cdots (5)$$

Channel estimation value synthesis section 211 enters channel estimation value $\beta(n)$ of an individual channel signal from channel estimation section 207, channel estimation value $\alpha a(n)$ of common pilot channel signal A from channel estimation section 208 and channel estimation value $\alpha b(n)$ of common pilot channel signal B from channel estimation section 209 and amplitude coefficient "a" and amount of phase rotation θ from amplitude/phase rotation amount estimation section 301.

Then, channel estimation value synthesis section 211 calculates final channel estimation value $\xi(n)$ from expression (6) below and outputs to demodulation section 212.

$$\xi(n)= \alpha a(n)+a\times \exp(j\theta)\times \alpha b(n)+\beta(n) \quad \cdots (6)$$

Thus, it is possible to improve the reliability of channel estimation values by carrying out channel estimations based on the amplitude coefficient, the amount of phase rotation, channel estimation values of common pilot channel signals even when the base station carries out transmission by changing the amplitudes of individual channel signals.

(Embodiment 3)

When a maximum Doppler frequency of fading is low and a fading variation is moderate, it is possible to

improve the reliability of channel estimation values by averaging fading estimation values over a plurality of reception slots.

However, as described above, when transmission diversity is introduced to a radio communication system, reception slots become discontiguous, and therefore it is not possible to average channel estimation values over a plurality of slots.

Embodiment 3 is intended to solve this problem and describes a case where transmission diversity is introduced and channel estimation values are synthesized over a plurality of slots.

FIG.9 is a block diagram showing a configuration of a communication terminal according to Embodiment 3 of the present invention. In the communication terminal shown in FIG.9, the same components as those in the communication terminal in FIG.5 will be assigned the same reference numerals as those in FIG.5 and explanations thereof will be omitted.

The communication terminal shown in FIG.9 has a configuration of the communication terminal shown in FIG.5 with multiple channel estimation value synthesis section 401 added.

FIG.10 is a block diagram showing an internal configuration of multiple channel estimation value synthesis section 401.

In FIG.10, delay circuit 501 stores a channel estimation value at current time (n) and delay circuit

502 stores a channel estimation value at time (n-1), 1 slot ahead.

Delay circuit 503 stores the amount of phase rotation at current time (n) and delay circuit 504 stores the amount of phase rotation at time (n-1), 1 slot ahead. Then, addition circuit 505 calculates a difference between the amount of phase rotation at time (n) and the amount of phase rotation at time (n-1).

Phase rotation circuit 506 corrects the amount of phase rotation from time (n-1) to time (n) with respect to the channel estimation value at time (n-1) output from delay circuit 502 based on the calculation result of addition circuit 505.

Then, synthesis circuit 507 synthesizes the corrected channel estimation value at time (n-1) output from phase rotation circuit 506 and the channel estimation value at time (n) output from delay circuit 502.

Thus, by correcting a channel estimation value at a time 1 slot ahead and synthesizing this correction result and the channel estimation value at the current time, it is possible to synthesize channel estimation values over a plurality of slots and thereby improve the reliability of channel estimation values.

This embodiment describes the case where the channel estimation value at a time 1 slot ahead is corrected and synthesized with a channel estimation value at the current time, but the present invention is

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not limited to a time 1 slot ahead, and it is possible to apply the same correction processing to a channel estimation value at a time any number of preceding reception slots ahead and synthesize it with the channel estimation value at the current time.

Embodiment 3 can be combined with Embodiment 2 and it is possible to synthesize channel estimation values over a plurality of slots even when the base station carries out transmission by changing the amplitudes of individual channel signals.

As described above, the communication terminal apparatus and channel estimation method of the present invention can improve the reliability of channel estimation values in a radio communication system using transmission diversity by using channel estimation values of common pilot channel signals, etc.

This application is based on the Japanese Patent Application No.HEI 11-241621 filed on August 27, 1999, entire content of which is expressly incorporated by reference herein.

Industrial Applicability

The present invention is ideally applicable to a CDMA-based radio communication system.

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What is claimed is:

1. A communication terminal apparatus comprising:

first channel estimating means for estimating a common pilot channel at a first antenna of a base station apparatus and outputting a first estimation value;

second channel estimating means for estimating a common pilot channel at a second antenna of the base station apparatus and outputting a second estimation value;

third channel estimating means for estimating an individual channel and outputting a third estimation value;

phase rotation amount estimating means for estimating the amount of phase rotation of the individual channel at the second antenna based on a relationship between said first estimation value, said second estimation value and said third estimation value; and

channel estimation value synthesizing means for synthesizing a value obtained by rotating said second estimation value by said amount of phase rotation and said first estimation value and outputting the synthesized estimation value.

2. The communication terminal apparatus according to claim 1, wherein the phase rotation amount estimating means calculates a first synthesized value by synthesizing a value obtained by rotating the second

estimation value by a candidate amount of phase rotation and the first estimation value and estimates the candidate amount of phase rotation whose first synthesized value is most orthogonal to the third estimation value as the amount of phase rotation of the individual channel at the second antenna, and the channel estimation value synthesizing means synthesizes a value obtained by rotating said second estimation value by said amount of phase rotation and said first estimation value and outputs the synthesized estimation value.

3. The communication terminal apparatus according to claim 1, wherein the phase rotation amount estimating means calculates a first synthesized value by synthesizing a value obtained by rotating the second estimation value by a candidate amount of phase rotation and multiplying by a candidate amplitude coefficient and the first estimation value and estimates the combination of said candidate amount of phase rotation and said candidate amplitude coefficient whose said first synthesized value is most orthogonal to said third estimation value as the amount of phase rotation and amplitude coefficient of the individual channel at the second antenna, and the channel estimation value synthesizing means synthesizes a value obtained by rotating said second estimation value by said amount of phase rotation and multiplying by said amplitude coefficient and said first estimation value and outputs

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the synthesized estimation value.

4. The communication terminal apparatus according to claim 1, comprising a multiple channel estimation value synthesizing means for synthesizing a value obtained by correcting the amount of phase rotation with respect to the synthesized estimation value of the preceding reception slot and the current synthesized estimation value.

5. A base station apparatus that carries out radio communication with the communication terminal apparatus according to claim 1 using transmission diversity.

6. A channel estimation method comprising the steps of:

calculating a first estimation value by estimating a common pilot channel at a first antenna of a base station apparatus;

calculating a second estimation value by estimating a common pilot channel at a second antenna;

calculating a third estimation value by estimating an individual channel;

calculating a first synthesized value by synthesizing a value obtained by rotating the second estimation value by a candidate amount of phase rotation and the first estimation value;

estimating the candidate amount of phase rotation whose first synthesized value is most orthogonal to the

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third estimation value as the amount of phase rotation of the individual channel at the second antenna; and

synthesizing a value obtained by rotating said second estimation value by said amount of phase rotation and said first estimation value and outputting the synthesized estimation value.

7. A channel estimation method comprising the steps of:

calculating a first estimation value by estimating a common pilot channel at a first antenna of a base station apparatus;

calculating a second estimation value by estimating a common pilot channel at a second antenna;

calculating a third estimation value by estimating an individual channel;

calculating a first synthesized value by synthesizing a value obtained by rotating the second estimation value by a candidate amount of phase rotation and multiplying by a candidate amplitude coefficient and the first estimation value;

estimating the combination of said candidate amount of phase rotation and candidate amplitude coefficient whose said first synthesized value is most orthogonal to said third estimation value as the amount of phase rotation and amplitude coefficient of the individual channel at the second antenna; and

synthesizing a value obtained by rotating said second estimation value by said amount of phase rotation

and multiplying by said amplitude coefficient and said first estimation value and outputting the synthesized estimation value.

8. The channel estimation method according to claim 6 that synthesizes a value obtained by correcting the amount of phase rotation with respect to the synthesized estimation value of the preceding reception slot and the current synthesized estimation value.

ABSTRACT

Phase rotation amount estimation section 210 rotates a channel estimation value of the common pilot channel B signal by a candidate amount of phase rotation θ (θ=0, 180) and synthesizes the rotated channel estimation value and the channel estimation value of the common pilot channel A signal. Then, phase rotation amount estimation section 210 estimates an amount of phase rotation having this synthesis result most orthogonal to the channel estimation value of the individual channel signal as the amount of phase rotation. Channel estimation value synthesis section 211 synthesizes a value obtained by rotating the channel estimation value of the common pilot channel B signal by an amount of phase rotation θ and the channel estimation value of the common pilot channel A signal. This allows a radio communication system using transmission diversity to improve the reliability of channel estimation values.

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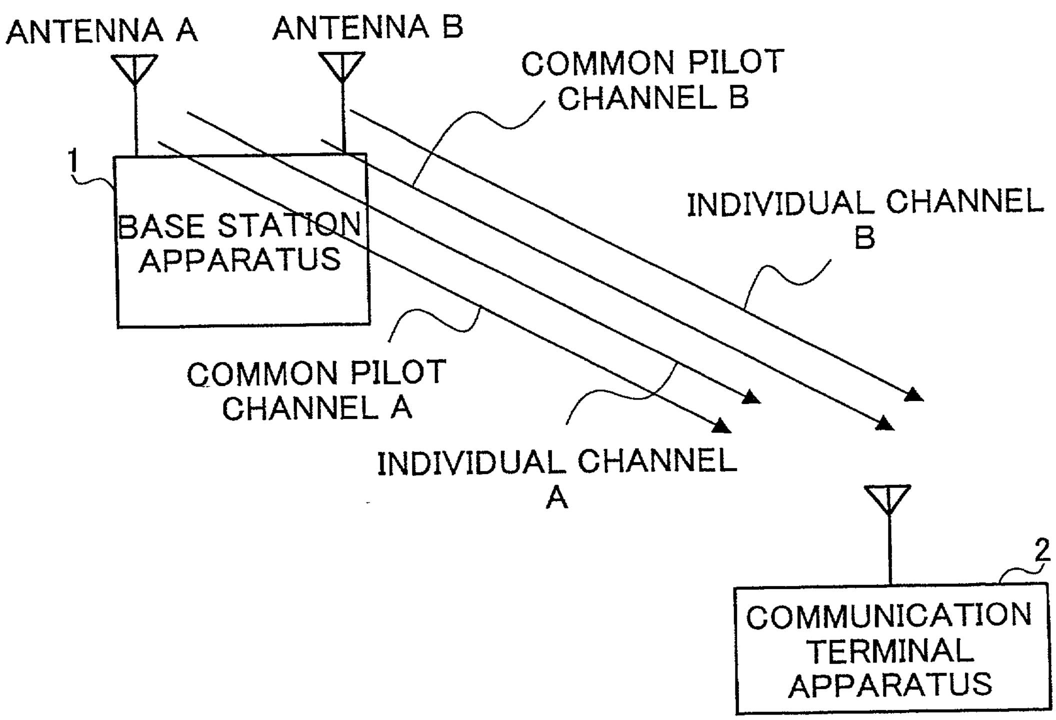

ANTENNA A
ANTENNA B
COMMON PILOT
CHANNEL B
1
BASE STATION
APPARATUS
INDIVIDUAL CHANNEL
B
COMMON PILOT
CHANNEL A
INDIVIDUAL CHANNEL
A
2
COMMUNICATION
TERMINAL
APPARATUS

FIG.1

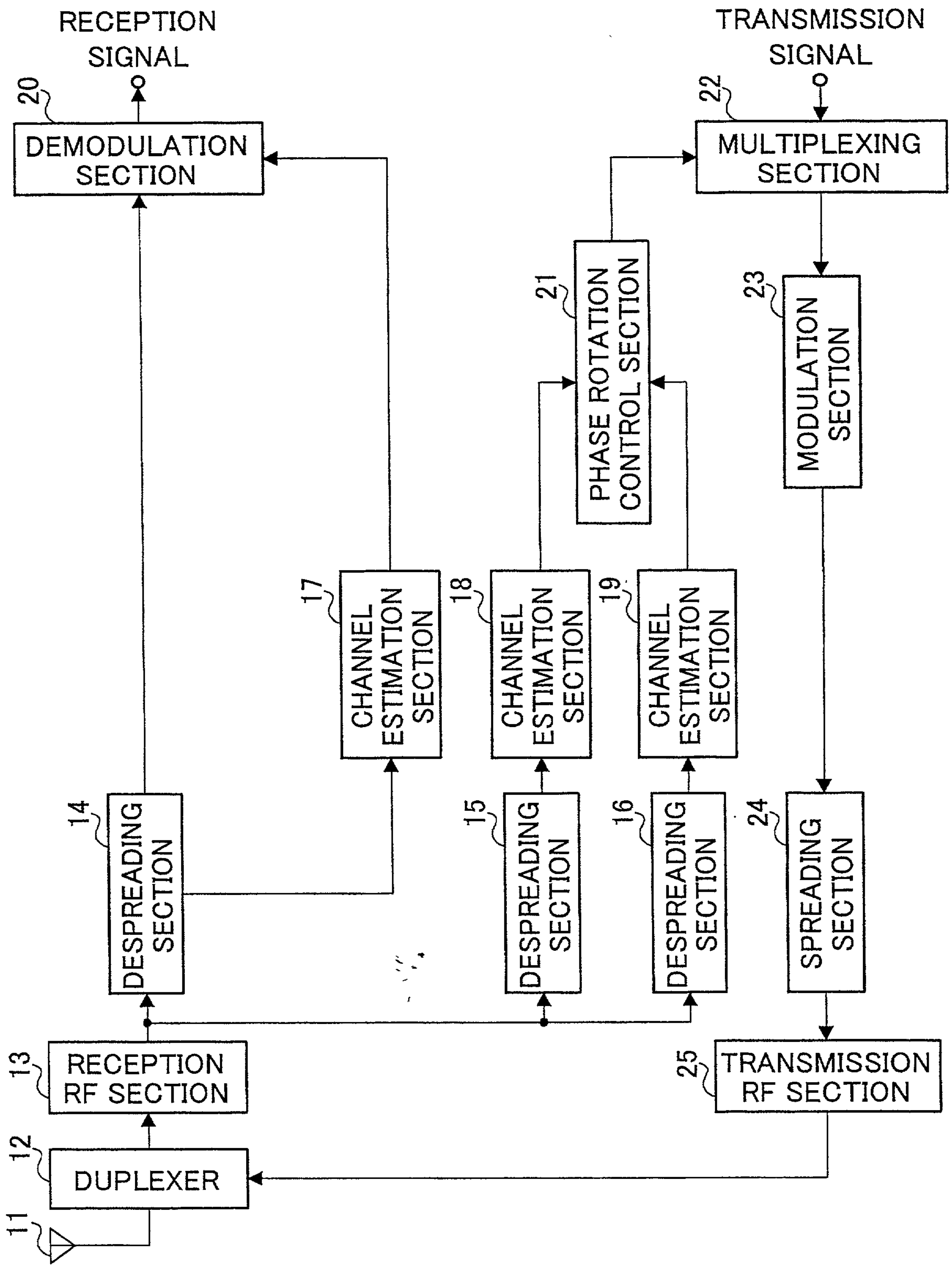

RECEPTION SIGNAL
TRANSMISSION SIGNAL
20
DEMODULATION SECTION
22
MULTIPLEXING SECTION
21
PHASE ROTATION CONTROL SECTION
23
MODULATION SECTION
17
CHANNEL ESTIMATION SECTION
18
CHANNEL ESTIMATION SECTION
19
CHANNEL ESTIMATION SECTION
14
DESPREADING SECTION
15
DESPREADING SECTION
16
DESPREADING SECTION
24
SPREADING SECTION
13
RECEPTION RF SECTION
25
TRANSMISSION RF SECTION
12
DUPLEXER
11

FIG.2

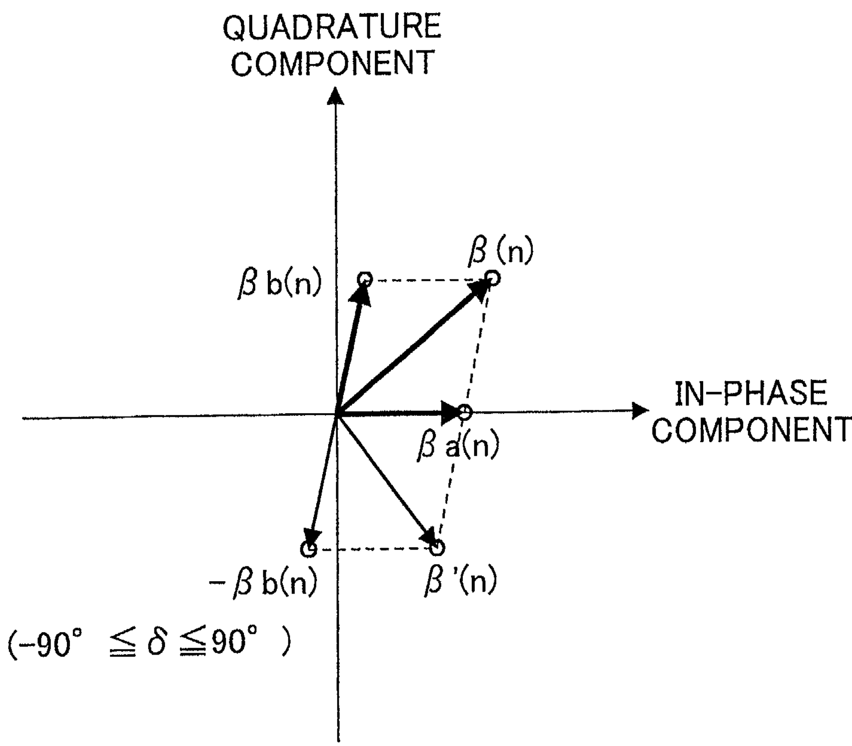

QUADRATURE COMPONENT
IN-PHASE COMPONENT
β (n)
β b(n)
β a(n)
−β b(n)
β '(n)
(−90° ≦ δ ≦ 90°)

FIG.3A

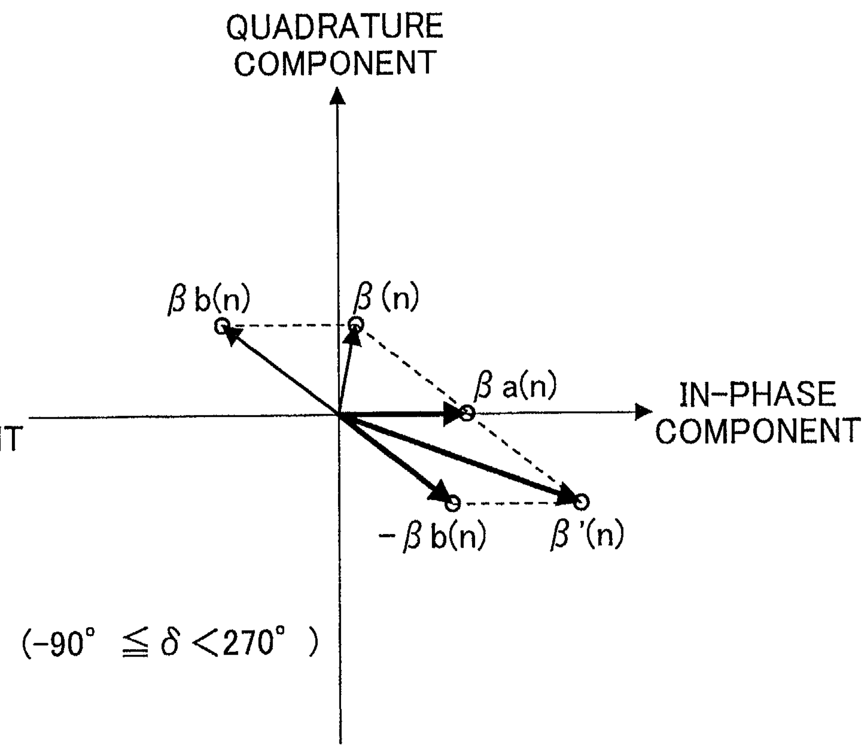

QUADRATURE COMPONENT
IN-PHASE COMPONENT
β b(n)
β (n)
β a(n)
−β b(n)
β '(n)
(−90° ≦ δ < 270°)

FIG.3B

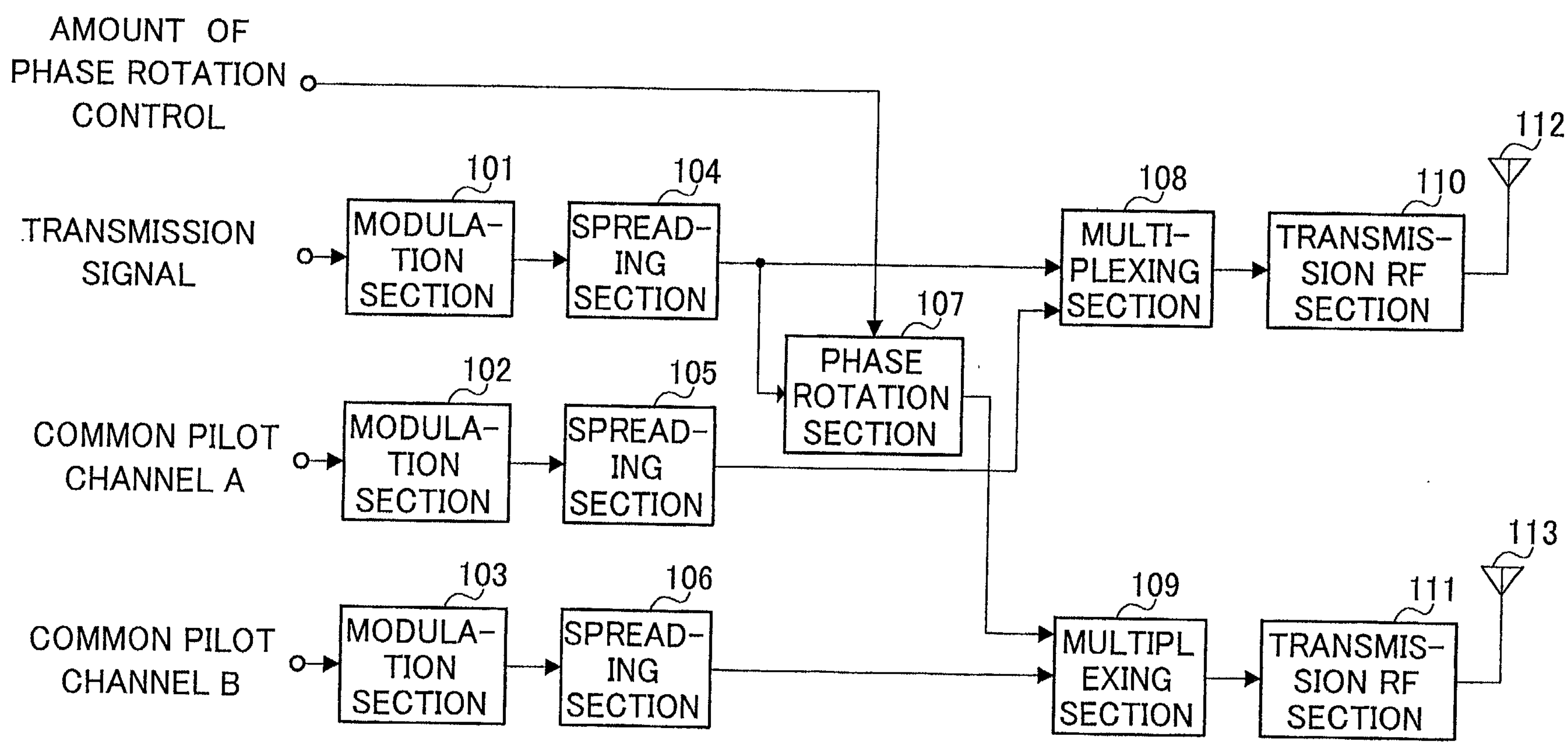
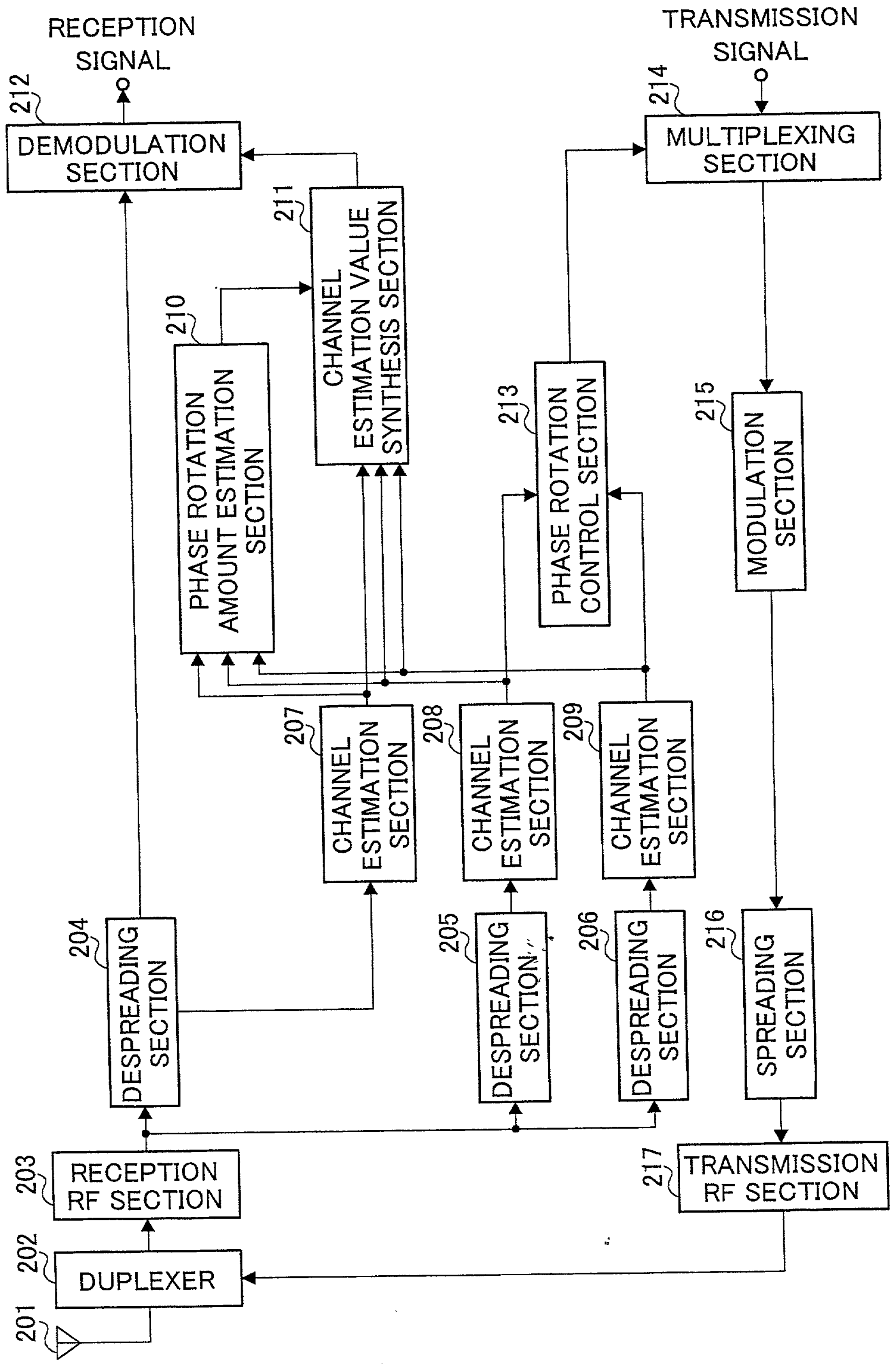

AMOUNT OF PHASE ROTATION CONTROL
TRANSMISSION SIGNAL
COMMON PILOT CHANNEL A
COMMON PILOT CHANNEL B
101
MODULA-TION SECTION
102
MODULA-TION SECTION
103
MODULA-TION SECTION
104
SPREAD-ING SECTION
105
SPREAD-ING SECTION
106
SPREAD-ING SECTION
107
PHASE ROTATION SECTION
108
MULTI-PLEXING SECTION
109
MULTIPL EXING SECTION
110
TRANSMIS-SION RF SECTION
111
TRANSMIS-SION RF SECTION
112
113

FIG.4



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212
DEMODULATION SECTION
TRANSMISSION SIGNAL
214
MULTIPLEXING SECTION
211
CHANNEL ESTIMATION VALUE SYNTHESIS SECTION
210
PHASE ROTATION AMOUNT ESTIMATION SECTION
213
PHASE ROTATION CONTROL SECTION
215
MODULATION SECTION
207
CHANNEL ESTIMATION SECTION
208
CHANNEL ESTIMATION SECTION
209
CHANNEL ESTIMATION SECTION
204
DESPREADING SECTION
205
DESPREADING SECTION
206
DESPREADING SECTION
216
SPREADING SECTION
203
RECEPTION RF SECTION
217
TRANSMISSION RF SECTION
202
DUPLEXER
201

FIG.5

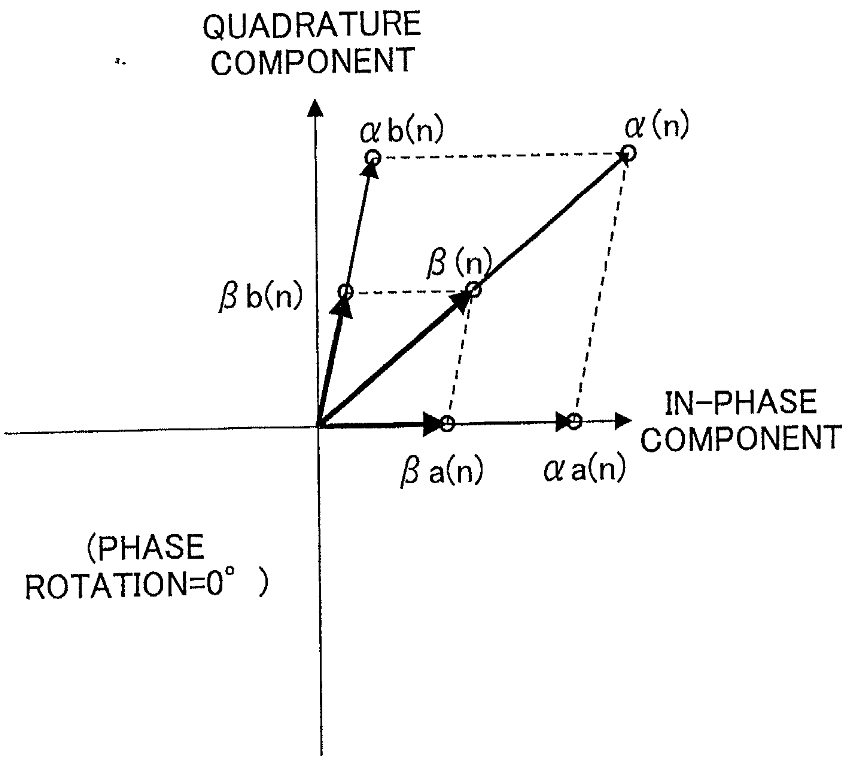
QUADRATURE
COMPONENT
αb(n)
α(n)
βb(n)
β(n)
IN-PHASE
COMPONENT
βa(n)
αa(n)
(PHASE
ROTATION=0°)

FIG.6A

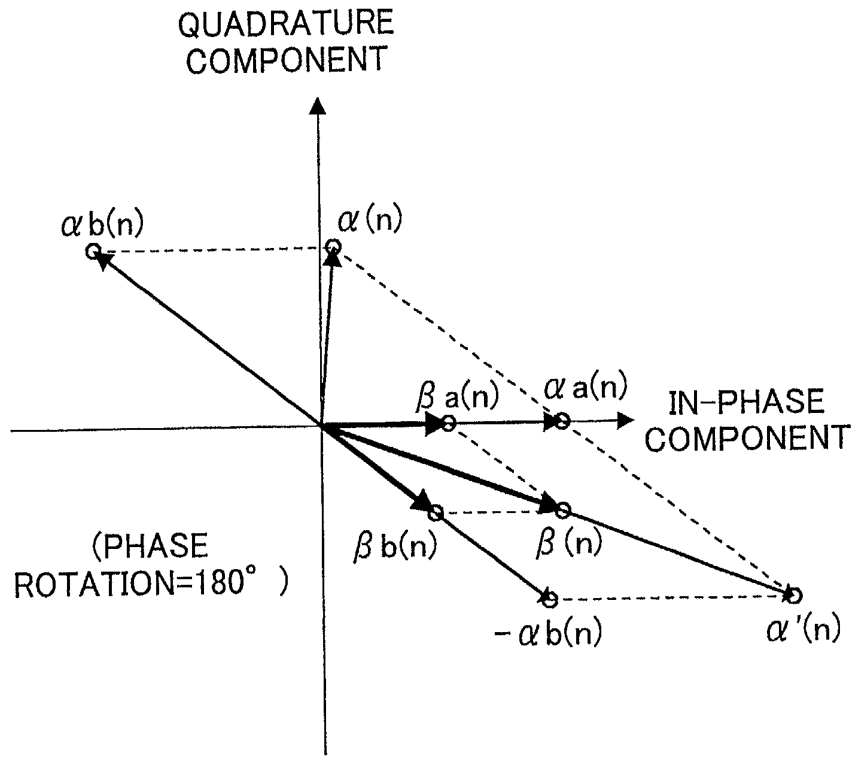
QUADRATURE
COMPONENT
αb(n)
α(n)
βa(n)
αa(n)
IN-PHASE
COMPONENT
(PHASE
ROTATION=180°)
βb(n)
β(n)
−αb(n)
α'(n)

FIG.6B

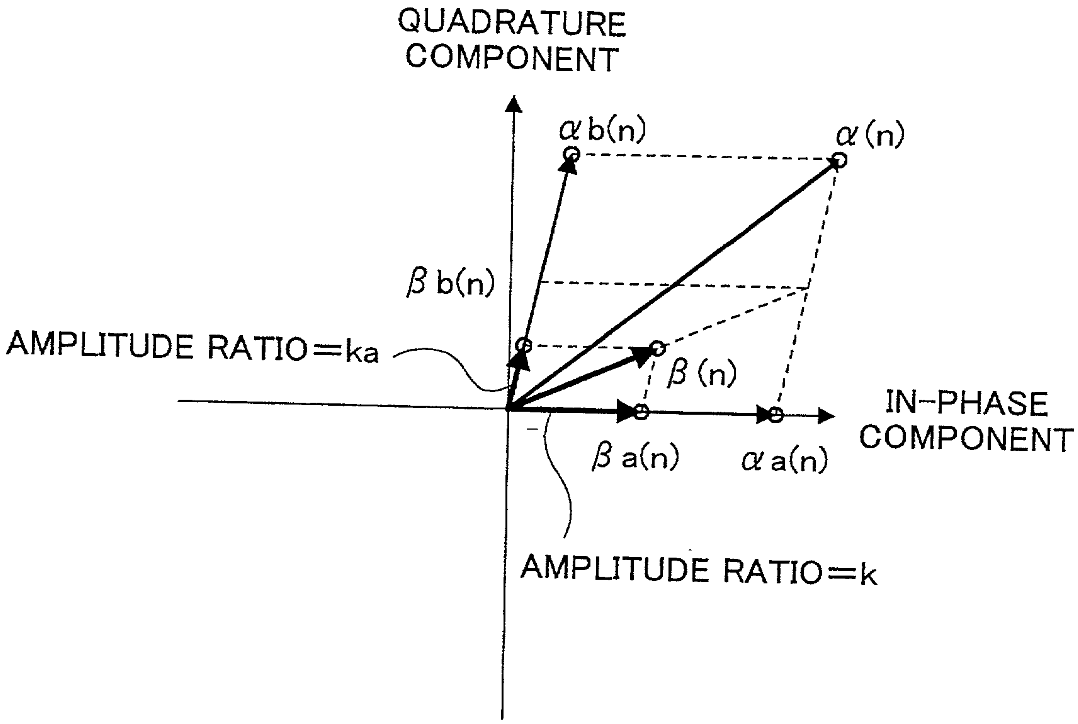

FIG.7

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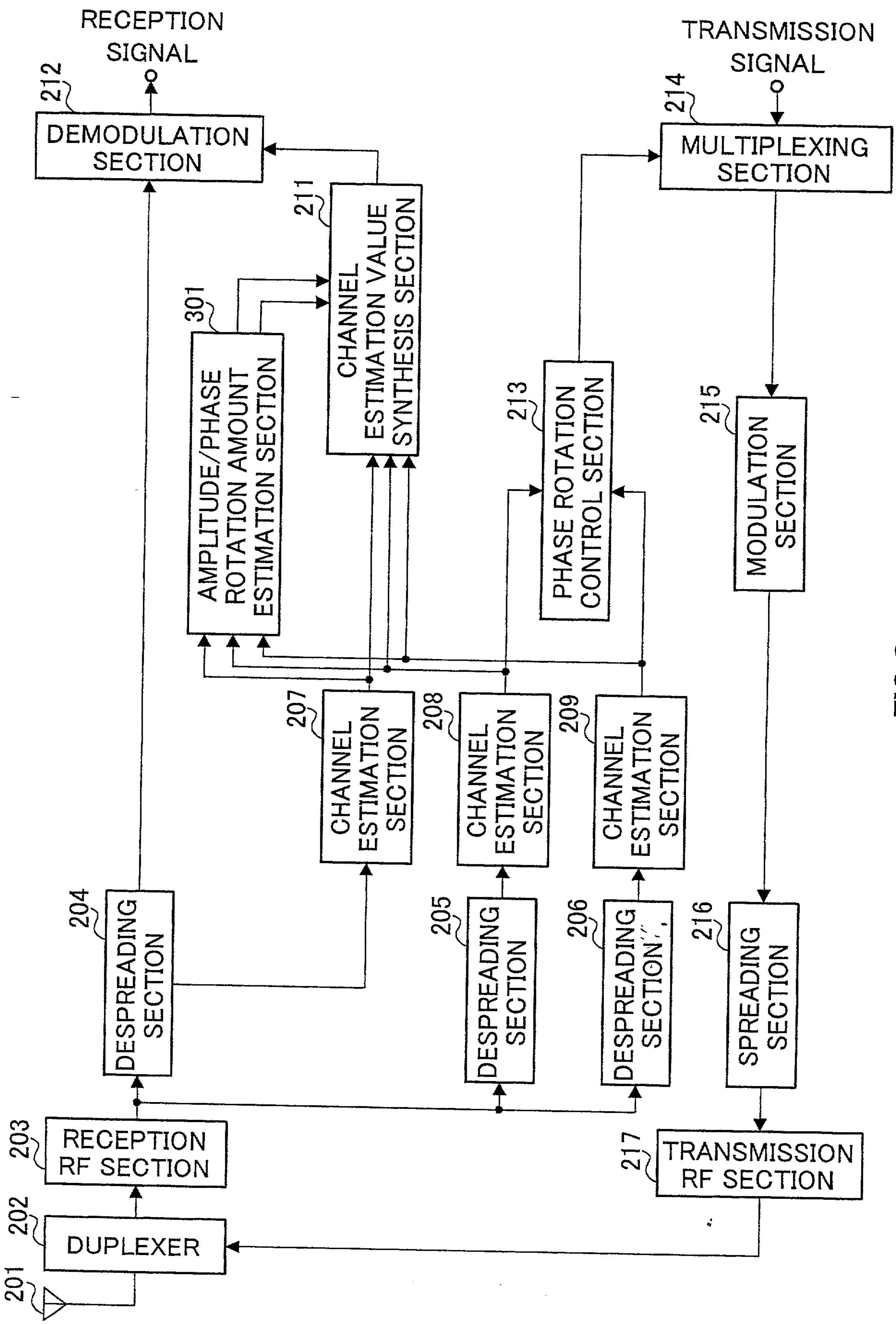
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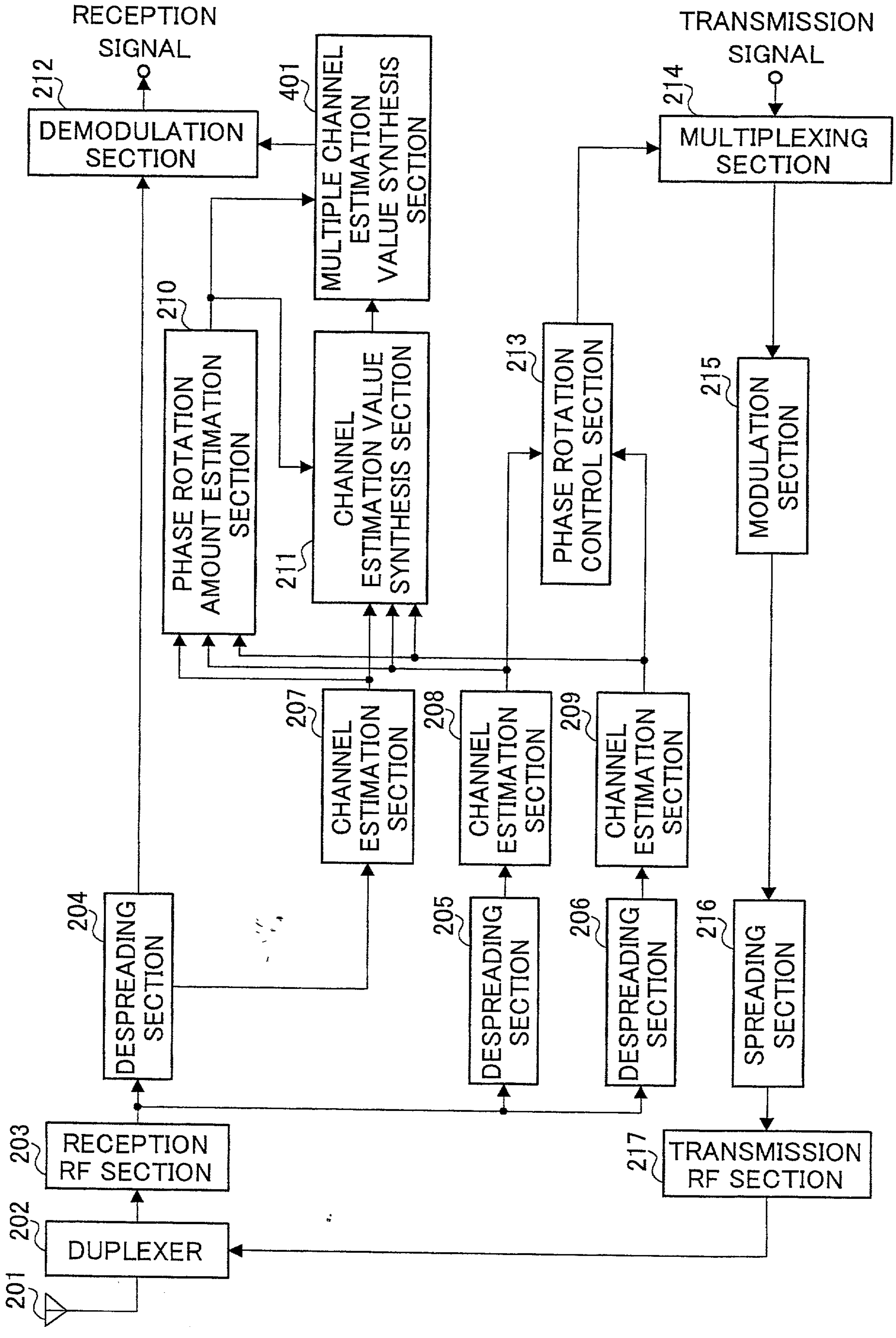
TRANSMISSION SIGNAL
212
DEMODULATION SECTION
214
MULTIPLEXING SECTION
211
CHANNEL ESTIMATION VALUE SYNTHESIS SECTION
301
AMPLITUDE/PHASE ROTATION AMOUNT ESTIMATION SECTION
213
PHASE ROTATION CONTROL SECTION
215
MODULATION SECTION
207
CHANNEL ESTIMATION SECTION
208
CHANNEL ESTIMATION SECTION
209
CHANNEL ESTIMATION SECTION
204
DESPREADING SECTION
205
DESPREADING SECTION
206
DESPREADING SECTION
216
SPREADING SECTION
203
RECEPTION RF SECTION
217
TRANSMISSION RF SECTION
202
DUPLEXER
201

FIG.8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TRANSMISSION SIGNAL
212
DEMODULATION SECTION
401
MULTIPLE CHANNEL ESTIMATION VALUE SYNTHESIS SECTION
214
MULTIPLEXING SECTION
210
PHASE ROTATION AMOUNT ESTIMATION SECTION
211
CHANNEL ESTIMATION VALUE SYNTHESIS SECTION
213
PHASE ROTATION CONTROL SECTION
215
MODULATION SECTION
207
CHANNEL ESTIMATION SECTION
208
CHANNEL ESTIMATION SECTION
209
CHANNEL ESTIMATION SECTION
204
DESPREADING SECTION
205
DESPREADING SECTION
206
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203
RECEPTION RF SECTION
217
TRANSMISSION RF SECTION
202
DUPLEXER
201

FIG.9

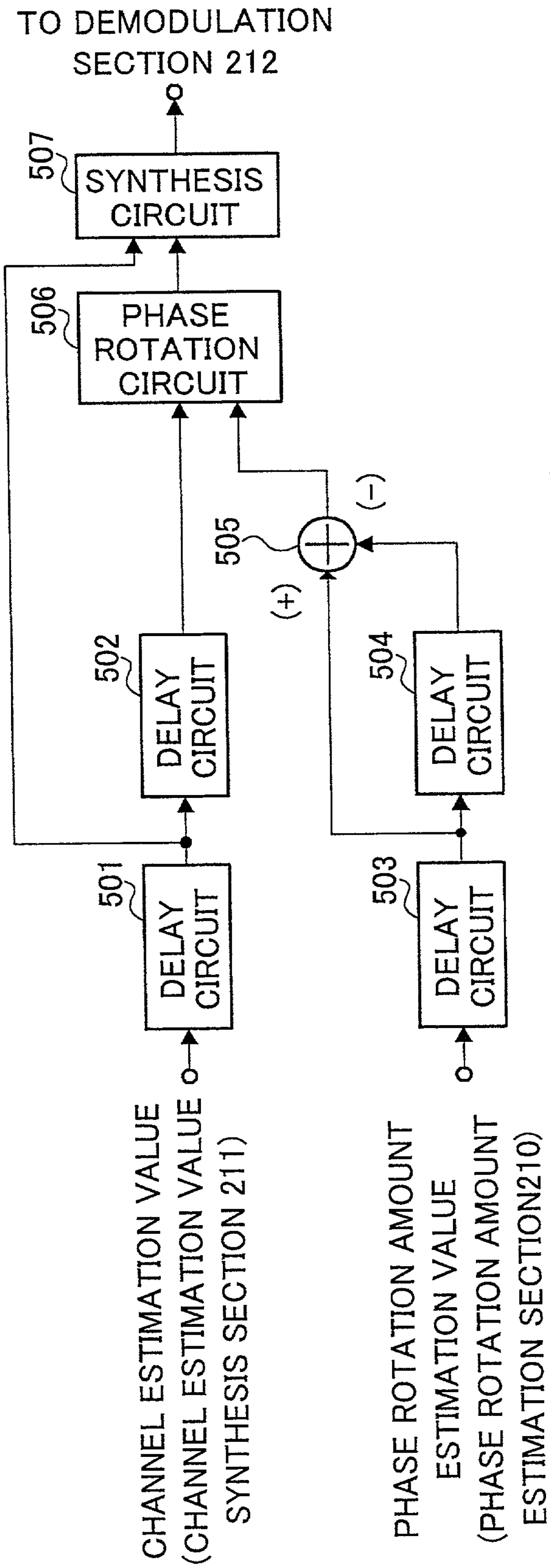
TO DEMODULATION
SECTION 212
507
SYNTHESIS
CIRCUIT
506
PHASE
ROTATION
CIRCUIT
505
(−)
(+)
502
DELAY
CIRCUIT
504
DELAY
CIRCUIT
501
DELAY
CIRCUIT
503
DELAY
CIRCUIT
CHANNEL ESTIMATION VALUE
(CHANNEL ESTIMATION VALUE
SYNTHESIS SECTION 211)
PHASE ROTATION AMOUNT
ESTIMATION VALUE
(PHASE ROTATION AMOUNT
ESTIMATION SECTION210)

FIG.10

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: COMMUNICATION TERMINAL APPARATUS AND CHANNEL ESTIMATION METHOD

the specification of which 2 (file no ____________)

(check at least one) 3 [x] is attached hereto
4 [ ] was filed on ________ as (5) U.S. Application Serial No. ____________
6 [ ] and was amended ____________ (if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.	7 [x]	was filed as PCT international application
	8	Number PCT/JP00/05622
	9	on August 23, 2000
		and was amended under PCT Article(s) 19 and/or 34
	10	on ____________ (if applicable).
	11	priority date claimed in PCT International Application
		JAPAN (Country) — JP11-241621 (Number) — 27/August /1999 (Day/Month/Year Filed)

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119 — Priority Claimed

	Country	Number	Day/Month/Year Filed	Yes	No
12a				[ ]	[ ]
				[ ]	[ ]

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

12b ________ Application No. ________ Day/Month/Year Filed ________ Application No. ________ Day/Month/Year Filed

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application	I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application. 13 ________ (U.S. Application Number) ________ (U.S. Filing Date) ________ Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

3 James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036, TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.

See page 2 for signature lines

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other side for instructions for completing this form

STEVENS, DAVIS, MILLER & MOSHER, L.L.P.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

14a	Typewritten Full Name of Sole or First Inventor	**Katsuhiko** (Given Name)	(Middle Name)	**HIRAMATSU** (Family Name)
15a	Inventor's Signature	Katsuhiko		Hiramatsu
16a	Date of Signature	March (Month)	23 (Day)	2001 (Year)
17a	Residence	**Yokosuka-shi** JPX (City)	**Kanagawa** (State or Province)	**JAPAN** (Country)
18a	Citizenship	**JAPAN**		
19a	Post Office Address *(Insert complete mailing address, including country)*	**2-56-14-1212, Kinugasasakae-cho, Yokosuka-shi, Kanagawa 238-0031 JAPAN**		
14b	Typewritten Full Name of Sole or First Inventor	Given Name	Middle Name	Family Name
15b	Inventor's Signature			
16b	Date of Signature	Month	Day	Year
17b	Residence	City	State or Province	Country
18b	Citizenship			
19b	Post Office Address *(Insert complete mailing address, including country)*			
14c	Typewritten Full Name of Sole or First Inventor	Given Name	Middle Name	Family Name
15c	Inventor's Signature			
16c	Date of Signature	Month	Day	Year
17c	Residence	City	State or Province	Country
18c	Citizenship			
19c	Post Office Address *(Insert complete mailing address, including country)*			
14d	Typewritten Full Name of Sole or First Inventor	Given Name	Middle Name	Family Name
15d	Inventor's Signature			
16d	Date of Signature	Month	Day	Year
17d	Residence	City	State or Province	Country
18d	Citizenship			
19d	Post Office Address *(Insert complete mailing address, including country)*			

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.

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INSTRUCTIONS FOR COMPLETION OF THIS FORM

line 1 Insert the same title as is used on the specification and in the assignment.

line 2 Is optional but is provided so that you can use it to identify more readily an application prior to the time that the Patent Office application serial number is assigned. We suggest that the specification, drawings and declaration always bear a file number since it can help to get the papers together in case they become inadvertently separated. In instances where the specification is filed without a signed declaration form (under 37 CFR §1.53) a file number on a later-received separate form will assist us in associating it with the correct case.

line 3 Check this box if the specification, claims and drawing (if any) are attached to this declaration form, e.g., when filing a new patent application.

lines 4-5 Are only used in an instance where the application is already on file and the declaration from is being separately filed, e.g.,when the application was originally filed without a signed declaration or where the Patent Office has required a new declaration because of a deficiency in the original declaration. In such an instance the Patent Office will require that lines 4 and 5 be completed with the filing date and application serial number already assigned.

line 6 Is used in conjunction with line 5 but only when there have been one or more amendments to the specification or claims. Line 6 is also used when the Examiner requires a new declaration because claims inserted by amendment cover subject matter not originally claimed (37 CFR §1.67).

lines 7-11 Are for PCT (Patent Cooperation Treaty) cases and are used only when you are entering the U.S. National phase (Chapter I or II) based upon a previously filed PCT International application designating the U.S.

line 7 Check this box if this is a PCT National Phase application.

line 8 Insert PCT International application number.

line 9 Insert date of filing of PCT International application.

lines 10-11 Insert the date of all amendments filed in the PCT International application. Such amendments are optional, so this line at times will not be used.

line 12a Is used in the following instances:

(i) If a single priority is being claimed from a foreign application you need to list only the first-filed application; you do not need to list other countries if all applications were filed within one year of the U.S. filing.

(ii) If multiple priorities are being claimed, from a plurality of applications filed in one or more countries, you must list the first filed application for each aspect of the invention. Example: if aspect A of the invention was disclosed in an application filed 11 months earlier in country X and aspect B was disclosed 9 months earlier in an application filed in country Y, then the applications in both countries X and Y must be identified. Only the first application for each aspect of the invention needs to be identified provided all applications on that aspect were filed within one year prior to the U.S. filing.

(iii) If a non-priority application is being filed you must list all applications in all countries where corresponding foreign applications were filed more than one year prior to the U.S. filing. This is so the Examiner can check to see if any of those applications were published or patented early enough to be prior art against the U.S. application.

(iv) If there are more than two applications to be listed we suggest that you type in on this form only "See attached Schedule A" and then list all of the previous applications on an attached sheet.

line 12b Is used to claim priority under 35 USC §119(e) based on a provisional application filed within one year of the filing of the instant application. More than one provisional application may be identified provided neither was filed more than one year earlier.

line 13 This block is used only in instances where there is a previously filed U.S. non-provisional application which was copending at the time the present application was (or is being) filed. that previous application could be a U.S. non-provisional application or the National Phase of a PCT allocation. In such a case the present application may be entitled to the priority of the previous application's U.S. filing date (and consequently the foreign priority thereof) provided the present application is identified as a continuing application (continuation, divisional or continuation-in-part) of the earlier (parent) application. If the foregoing is applicable, please fill in one line for each such prior application.

line 14 Type the inventor's proper legal name in the order specified, e.g., "John B. JONES" or "J. Bob JONES" if the inventor so prefers. It is not acceptable to use only initials such as "J. B. JONES."

line 15 The inventor's "signature" may be his (or her) usual manner of signing but it is preferable that the inventor simply write his (or her) name in his (or her) own cursive handwriting in the same order as on line 14, e.g., given name, middle initial and Family name.

line 16 Insert the actual date of signature.

line 17 Insert simply the city and state or country, e.g., "Paris, France", of the inventor's residence, not citizenship. No street address or postal code is required on this line.

line 18 Insert the inventor's citizenship. The statement of citizenship (or subject of) is a statutory requirement (35 USC §115). Simply the name of the country of citizenship, e.g., "Japan" is sufficient.

line 19 Insert the inventor's mailing address. The purpose of requiring the post office address is to enable the Patent Office to communicate directly with the inventor if desired, such as in the case of death of the U.S. attorney. It should be the address where the inventor customarily receives his (or her) mail and should include the postal code. If applicable it can be the inventor's business address or address at place of employment.

Applicants are reminded that the U.S. Patent and Trademark Office has very strict requirements as to proper execution of an application. The applicant should make sure that he reviews the declaration, prior to signing to make sure the declaration properly identifies the application and all relevant information; and should review the specification and claims (including drawings, if any) before signing the declaration. Failure to do so will require the filing of a supplemental declaration --- 37 CFR §1.67(c).

Any handwritten changes to the specification, claims or drawings must be in ink personally by all of the inventors prior to signing the declaration and the adjacent left margin must be initialed and dated by all of the inventors, e.g., "JBJ 6-9-91".

Please let us know if there are any questions regarding proper completion of this form. Thank you.

An assignment, a separate document requiring separate signature and dating may be enclosed. Please look for it and sign and date it in the same manner as in lines 15 and 16 above.